

## CHEMICAL DETERMINATION OF EVERYDAY HOUSEHOLD CHEMICALS

**Purpose:** It is important for chemists to be able to determine the composition of unknown chemicals. This can often be done by way of chemical tests. In this lab you will determine the chemical composition of some common household chemicals using common chemical tests.

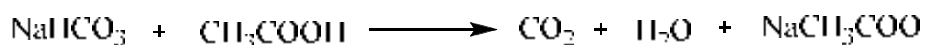
**Background:** Chemicals surround us at all times and encompass, literally, everything in our lives. We can taste, touch, see, and feel chemicals. We may not be able to see air, or taste the oxygen in it, but it makes up the wind that we can feel against our skin and hear blowing through trees. Although nearly all chemicals can do chemistry, not all chemicals in our lives actually do chemistry in the environment where they exist. Think about it, it would be impossible to sit in a plastic chair if the polymers that make it up were constantly breaking down; however, in a lab, chemists can easily break down polymers using very specific chemicals. You know that some chemicals can dissolve in other chemicals whereas others do not. Salt (sodium chloride) can dissolve in water whereas sand (silicon dioxide) does not. We refer to the ability to dissolve as solubility. Salt is water soluble, and sand is water insoluble.

When a chemical is dissolved, chemistry can happen, but that doesn't mean it always does. If we evaporate salt water, the salt will be recovered. However, we can add other chemicals to the salt water that will react with the sodium chloride to give a new chemical. When we evaporate the water in those cases, the salt no longer exists, but a new chemical can be found—this means a chemical reaction has occurred. The new chemical may or may not be soluble in the water. If it is soluble, you won't see much of a change in the solution. If it is insoluble, you will see the solution get cloudy. In this experiment, we will be using chemical reactions to identify the chemicals in ammonia, fertilizer, baking soda, table salt, and Epsom salt. Once you know how these respond to the chemical tests, you will be able to test an unknown compound to determine its composition by comparison. To understand the lab, you will need to know about chemical tests, equations, and several other terms defined below:

*Chemical tests:* Each chemical test answers a very specific question. We can ask; does table salt contain chloride? We *know* the answer is yes, we know that table salt is sodium chloride. However, this information was not always known. We could therefore use a chloride test to test for the presence of chloride. In the same respect, we could use a sodium test to test for the presence of sodium. In this way, we could positively identify the components of table salt as both sodium and chloride. This is important to chemists who encounter new chemicals, both in the environment and in lab. If we want to know if a lake contains mercury, we can use a mercury test. If we want to know if that same lake has high lead levels, we can use a different test.

*Chemical equations:* We can show *how* chemistry happens by writing chemical equations. These are expressions of our starting materials, products, and sometimes temperature, using the formulas for each chemical.

A good example of this is the baking soda-vinegar reaction you may have seen in science-fair volcanoes:



In this equation, sodium bicarbonate reacts with acetic acid to yield carbon dioxide, water, and sodium acetate. Although at this point you probably don't recognize many of these formulas, you can see very clearly that the starting materials (on the left side of the arrow) are different than the products (on the right side of the arrow). This shows that chemistry has happened.

*Concentration:* The concept of concentration is important to many reactions. Concentration deals with how much of a solute is present in a solvent at any time. There are several ways to measure concentration. If we have 2 g NaCl in 100 mL of water, we can report the concentration as 2 g NaCl/100 mL H<sub>2</sub>O. We can also report it as a ratio, 1 g NaCl:50 mL H<sub>2</sub>O. A very common way of reporting concentrations in chemistry is using *molarity*. Molarity is defined as moles of solute per liter of solution (or simply, M). A mol (mole) is  $6.022 \times 10^{23}$  atoms (we have discussed this briefly in class). If we have 0.5 mol of NaCl in 1 liter of water, then our molarity is 0.5 M. We will learn how to calculate molarity in the future, but for now, realize it is simply a measurement of concentration for a solution.

*Salts:* When you think of salt you probably think of what you cook with. Chemists have another definition for salts. Salts can be thought of as an ionic compound that doesn't use H<sup>+</sup> (hydronium ion) as the cation and doesn't use OH<sup>-</sup> (hydroxide) or O<sup>2-</sup> (oxide) as the anion. In other words, most ionic compounds are considered salts by chemists. Most salts are soluble in water, but several aren't.

*Precipitate:* When, in the course of a chemical reaction, an insoluble material is formed that is visible in the reaction vessel. In a test tube reaction, a clear solution will turn cloudy when a precipitate forms. This typically means a non-soluble ionic compound has formed.

*Litmus paper:* Litmus paper is used as an indicator of certain chemicals. Blue litmus paper tests for one type of chemical, and red litmus paper tests for another. At the start of a reaction, the paper can be one color, and by the end, it has changed color in response to a new chemical that was made.

\*\*\*We will be using dangerous, caustic (things that corrode) chemicals in this lab, so it is important that you are very careful with them. Wear gloves if you prefer, and wash your hands if they are exposed to chemicals.

Equipment:

150-mL beaker

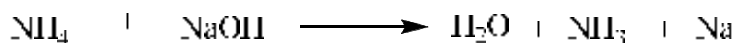
3 disposable pipettes

Several 15-cm test tubes and test tube rack

Red litmus paper

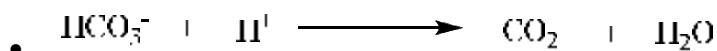
Procedure:

Testing for ammonia: Ammonium salts (NH<sub>4</sub><sup>+</sup>) are converted to ammonia (NH<sub>3</sub>) by the action of strong bases. Hence, one can test for the ammonium ion by adding sodium hydroxide (NaOH) and noting the familiar odor of NH<sub>3</sub> or by the use of red litmus. Ammonia turns red litmus blue. The net reaction is as follows:



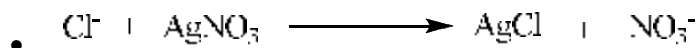
- Ammonium chloride—a stable ammonium salt
  - Place about 1 mL of 1 M  $\text{NH}_4\text{Cl}$  (ammonium chloride) in a test tube and hold a moist piece of red litmus paper over the mouth of the tube. Record your results on the data sheet.
  - Add 1 mL of 8 M  $\text{NaOH}$  and agitate carefully to mix. Test with the red litmus paper and record your results. You may need to carefully warm the reaction by heating it under hot tap water and testing again.
- Smelling salts—a very unstable ammonium salt
  - Hold a moist piece of red litmus over the mouth of an open jar of ammonium carbonate ( $(\text{NH}_4)_2\text{CO}_3$ ). Record your results. Carefully fan your hand over the jar to smell the now-familiar odor.
- Fertilizer
  - Place a pea size amount of fertilizer in a new test tube and add 1 mL of water. Test with red litmus paper and record your results.
  - Add 1 mL of 8 M  $\text{NaOH}$  and test as before with moist red litmus paper. Record your results.
  - Is fertilizer ammonia based or ammonium based?

Testing for carbonate: Bicarbonate ( $\text{HCO}_3^-$ ) and carbonate salts ( $\text{CO}_3^{2-}$ ) react with acids to form carbon dioxide (a gas) and water. We can test for the presence of these by adding acid and watching for the evolution of bubbles, that is,  $\text{CO}_2$  gas. The net reaction is as follows:



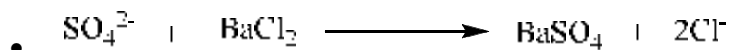
- Baking soda
  - In a small, clean test tube, place a pea size amount of baking soda ( $\text{NaHCO}_3$ ). Carefully add 1-2 drops of concentrated  $\text{H}_2\text{SO}_4$  (sulfuric acid). Record your observations.
  - Repeat the procedure using vinegar in place of sulfuric acid. Record the results.

Testing for chloride: Chloride salts react with silver nitrate ( $\text{AgNO}_3$ ) to form silver chloride ( $\text{AgCl}$ ). Although many chloride salts are water soluble, readily dissolving in water, silver chloride is quite insoluble and will precipitate out of the reaction. The reaction is shown below:



- Table salt
  - Place a pea size amount of table salt  $\text{NaCl}$  in a test tube and add 15 drops of water and one drop of 3 M  $\text{HNO}_3$ . Add 4 drops of a 0.1 M  $\text{AgNO}_3$  solution and swirl the test tube to mix the chemicals. Record your results.

Testing for sulfate: Sulfate salts ( $\text{SO}_4^{2-}$ ) react with barium salts ( $\text{Ba}^{2+}$ ) to form an insoluble precipitate, barium sulfate ( $\text{BaSO}_4$ ). Like the chloride salts above, sulfate salts tend to be quite soluble, but barium sulfate is insoluble. The reaction is shown below:



- Epsom salts
  - Place a pea size amount of Epsom salts ( $\text{MgSO}_4$ ) in a test tube and dissolve it in 1 mL of water. Add 1 drop of 3 M  $\text{HNO}_3$  and then 2 drops of a 0.2 M  $\text{BaCl}_2$  (barium chloride) solution. Record your results.

Determination of an unknown: You will be given an “unknown” chemical that is a sulfate, carbonate, or chloride salt. You will use the above tests and results from those tests to figure out which type of salt you have. Remember that for a positive test, your results need to match those from above (other reactions could happen, but will not give you a definitive answer on what you have in the tube).

- Put a pea size amount of your unknown into three different test tubes. Follow the tests for sulfate, carbonate, and chloride determination. Record your results.

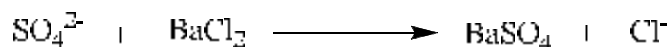
## CHEMICAL DETERMINATION OF EVERYDAY HOUSEHOLD CHEMICALS PRE-LAB

Name: \_\_\_\_\_

1. What is the common name for sodium chloride? \_\_\_\_\_
2. What is the common name for magnesium sulfate? \_\_\_\_\_
3. What is the common name for sodium bicarbonate? \_\_\_\_\_
4. When salt is dissolved in water, does a chemical change occur? \_\_\_\_\_
5. Think about your kitchen at home. What are two other chemicals that are dissolved in water, that do not seem to change physically? \_\_\_\_\_
6. If you add a chemical to a dissolved substance, and the solution turns cloudy, what has formed?  
\_\_\_\_\_

Is this a chemical or physical change? \_\_\_\_\_

7. What do you look for to determine if a chloride test is positive?  
\_\_\_\_\_
8. If you do a sulfate ( $\text{SO}_4^{2-}$ ) test on an unknown chemical and there is precipitation observed, what can you conclude?  
\_\_\_\_\_
9. You did the following reaction to determine if Epsom salts contained sulfate. Balance the equation.



10. How can you check for the presence of ammonia?  
\_\_\_\_\_  
\_\_\_\_\_
11. Are all salts soluble? \_\_\_\_\_



CHEMICAL DETERMINATION OF EVERYDAY HOUSEHOLD CHEMICALS DATA SHEET

Name: \_\_\_\_\_

Partner(s): \_\_\_\_\_

Unknown number: \_\_\_\_\_

Testing for ammonia:

1. Ammonium chloride

- Color of litmus in  $\text{NH}_4\text{Cl}$  litmus test \_\_\_\_\_
- Color of litmus in  $\text{NH}_4\text{Cl}$  with 8 M NaOH litmus test \_\_\_\_\_

2. Smelling salts—an unstable ammonium salt

- Color of litmus in  $(\text{NH}_4)_2\text{CO}_3$  test \_\_\_\_\_

3. Fertilizer

- Color of litmus in fertilizer litmus test \_\_\_\_\_
- Color of litmus in fertilizer with 8 M NaOH test \_\_\_\_\_
- If fertilizer ammonia or ammonium based? \_\_\_\_\_

Testing for carbonate:

1. Baking soda

- Baking soda with  $\text{H}_2\text{SO}_4$  observations  
\_\_\_\_\_  
\_\_\_\_\_

- Baking soda with vinegar test observations  
\_\_\_\_\_  
\_\_\_\_\_

Testing for chloride:

1. Table salt

- Salt with  $\text{HNO}_3$  and  $\text{AgNO}_3$  test observations

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Testing for sulfate:

1. Epsom salts

- Epsom salts with  $\text{HNO}_3$  and  $\text{BaCl}_2$  test observations

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Unknown chemical determination:

- Observations for sulfate test

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- Observations for carbonate test

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- Observations for chloride test

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- Which tests were positive?

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- Which tests were negative?

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Questions:

1. Did your unknown have a sulfate, carbonate, or chloride component? \_\_\_\_\_

2. Assume you have a mixture of sodium chloride and sodium carbonate. How would you determine that the sodium carbonate is present without getting a false positive test from the sodium chloride?

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3. Think about the issues regarding safety of chemicals, and the ease of using a chemical test to determine the presence of these chemicals. Where do YOU think a new chemical test would be useful in your home (lead tests already exist, as to pool testing kits)?

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